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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:		Atty. Docket No.:	004770.81503
Juha Ylitalo et al.			
Serial No.:	09/586,561	Group Art Unit:	2634
Filed:	June 2, 2000	Examiner:	Williams, Lawrence B.
For:	CLOSED LOOP FEEDBACK SYSTEM FOR IMPROVED DOWN LINK PERFORMANCE	Confirmation No.:	7618

DECLARATION UNDER 37 C.F.R. § 1.131

U.S. Patent and Trademark Office
Customer Service Window, Mail Stop Amendment
Randolph Building
401 Dulany Street
Alexandria, VA 22314

Sir:

We, JUHA YLITALO and MARCOS KATZ, hereby declare[1] that:

1) We are named as joint inventors of the above-captioned application, U.S. Application Serial No. 09/586,561, and all claims presently pending therein;
2) I, JUHA YLITALO, was formerly employed by Nokia Corporation (Nokia). Nokia is the assignee of the above-identified application.
3) I, MARCOS KATZ, was formerly employed by Nokia. Nokia is the assignee of the above-identified application.
4) We were employed by Nokia during development of the above-identified invention.
5) Prior to May 24, 2000, the filing date of Dabak et al. (U.S. Patent No. 6,594,473, hereinafter *Dabak*), we conceived of the invention recited in claims 14 and 39 of the

[1] Each numbered declaration is a joint declaration unless an individual reference has been made. In such a case, the referenced individual or individuals are making the numbered declaration.

above-captioned application, at least to the extent the claims are allegedly taught by *Dabak*, and diligently pursued constructive reduction to practice in the form of a patent application filed with the United States Patent & Trademark Office.

6) Conception occurred prior to May 24, 2000, as is evidenced by the Report of Invention and comments to a draft specification attached in Exhibit A (dates redacted). The Report of Invention and comments to a draft specification were prepared prior to May 24, 2000.

7) Support for at least claims 1, 14, 26, and 39, of the above-captioned application can be found, among other places, at least within the Report of Invention and comments to a draft specification (Exhibit A) prepared prior to May 24, 2000.

8) Support for claims 1 & 26, can be found, among other places, on pages 1 and 2 and in Figure 1 of Exhibit A. Support for claims 14 & 39, can be found, among other places, on pages 1-2 of Exhibit A.

9) Evidence of Diligence prior to the filing date of *Dabak* (May 24, 2000) and the constructive reduction to practice (the filing date of June 2, 2000) of the present application can be found in Exhibits B-C.

10) On May 17, 2000, Mr. Daniel E. Fisher (the original drafting attorney of this application, formerly of Banner & Witcoff, LTD.) sent a letter via express courier to one of the inventors, Mr. Juha T. Ylitalo, enclosing a revised draft application. A redacted copy of the first page of the letter is attached as Exhibit B.

11) On May 25, 2000, the inventors executed the Joint Declaration for Patent Application filed concurrently with the present application. A copy of the Joint Declaration for Patent Application is attached as Exhibit C.

12) On June 2, 2000, the present application was filed with the United States Patent and Trademark Office.

13) The forwarding of the draft application from our patent attorney and our execution of the Joint Declaration for Patent Application demonstrates diligence from before May 24, 2000, until the filing of the above-captioned patent application and the constructive reduction to practice of our invention.

14) All acts referred to in this Declaration were performed either in the United States, or in a WTO member country.

15) The attached Exhibit A has not been altered since it was originally prepared except for the redaction of references to dates on the document.

16) The attached Exhibit B provides an unaltered introduction to the first page of a document that demonstrates diligent pursuit of a constructive reduction to practice. The remaining portion of Exhibit B, including substantive comments, has been redacted.

17) The attached Exhibit C has not been altered since it was originally prepared.

18) Each of us individually represent that we are over 18 years of age and of competent mind.

19) All statements made of our own knowledge are true and all statements made on information and belief are believed to be true; and further, these statements were made with the knowledge that willful, false statement so made are punishable by fine or imprisonment or both, under 18 U.S.C. § 1001 and that such willful, false statements may jeopardize the validity of the above-identified application or any patent issuing thereon.

Respectfully submitted,

Juha T. Ylitalo	8.6.2005 Date
Marcos Katz	8.6.2005 Date

EXHIBIT A

Comments to Draft Specification and Patent Predisclosure Document

(Dates Redacted)

Comments to draft specifications (your ref. 4770.81503)

1 & 2. The assertion refers to the fact that the selection of beams is carried out by a) **the MS** in FDD systems, based on measurements done at the DL, or alternatively, b) by **the BS** in TDD systems, where UL and DL employ the same frequency. This is as a counterpart of what occurs if c) beam selection (or direction selection) in FDD is carried our by the MS, based on UL measurements. Since UL and DL use different frequencies (in FDD systems) any selection based on UL measurements will not necessarily be appropriate in DL (e.g., a direction with good response in UL may be in a deep fade when used in DL, due to the different frequencies). In a) and b) we can be sure that the selections are correct because they were done based on measurements using the actual DL frequency. In c) since UL and DL channels are uncorrelated in the short-term, there is no guarantee that the selection will be always correct.

The beam (or direction) selections made by the MS will tend to find the directions with favourable transmission conditions (e.g., low attenuation) towards MS. These directions may point directly to MS or ther may not, as in the case when signal from BS reaches the MS through reflections or scattering effects.

3. The selected beams may be adjacent or not. Contiguous beams define a common zone where the responses overlap. This common zone decreases very rapidly as angular separation of beams increases (e.g., non-adjacent selected beams). In order to exploit the diversity provided by two beams the MS must be able to separate (or resolve) the signals corresponding to each beam. In CDMA networks the Rake receiver at MS is able to separate signals received from different paths as long as they are separated in time (by the channel (delay spread) or by BS, by adding artificial delays) or/and code (by BS). In some cases some identifier (or signature) must be provided to the signals transmitted in each beam to facilitate the processing by the receiver. These could be a particular spreading code or pilot sequence used in each transmitted beam (codes are orthogonal to each other). The identifier is needed if downlink transmit diversity is employed: two signals are sent at the same time from different BS antennas but received with a SINGLE MS antenna --> the signals sum up at MS antenna; thus the MS must have some apriori reference by which it can can differentiate the two signals.

REPORT OF INVENTION

Invention name: An improved Tx-AA Downlink Diversity Scheme

Inventors: Marcos Katz and Juha Ylitalo NTC/RAS/WCDMA-Oulu.

Introduction and problem description

In one of the proposed closed loop transmit diversity scheme (Tx-AA modes of 3GPP) the Mobile Station (MS) estimates the downlink (DL) channel impulse responses from two Tx-antennas and uses this information to compute appropriate antenna weights for the two Base Station (BS) Tx-antennas. The Channel State Information (CSI) is transmitted depending on the particular mode using 1, 2, or 4 bits to the BS. In an ideal case, the exact values of CSI could be transmitted back to the BS and this would lead to optimum maximal ratio combining (MRC) at the transmitting side. However, this operation requires a large amount of bandwidth (extra UL overhead information) which will not be acceptable. In the currently proposed method (Tx-AA) few bits are reserved for this signalling purposes and hence only coarse CSI information is transmitted. In one mode of Tx-AA only phase information is transmitted (corresponding to coarse equal gain combining) while in another mode of Tx-AA both amplitude and phase angle information is fed back to the BS. The latter method corresponds to MRC and is optimal if interference can be modelled as AWGN.
The performance of the Tx-AA method greatly depends on the accuracy of CSI information. Tx-AA mode 4 achieves phase accuracy of 45° (3 bits) and amplitude accuracy of 1 bit (weight 0.2 or 0.8). ***In low-mobility radio environments the channel (and CSI) is changing slowly compared to the feedback rate.*** In the present Tx-AA the same (rough) information about the channel is repeatedly transmitted to the BS in consecutive bursts. ***Instead, a method is proposed here in which the accuracy of the CSI information is improved recursively during the time period during which the channel has not changed significantly.***

Description of the proposed method:

In general, and to reduce the amount of information to be transmitted, one antenna is set as a reference with corresponding channel or weight coefficient $1+j0$ (or amplitude = 1, phase = 0°). Thus, with M transmitting antennas, only differential information to the remaining M-1 antennas is transmitted back to the base station. In particular, when M = 2 only one complex coefficient is required. In what follows the case for M = 2 is analyzed. Fig. 1 illustrates the principle of the segmented feedback method for a particular case where both phase (Pha) and amplitude (Amp) are segmented in four parts and M = 2. The process is described by the following operations: 1) BTS transmits different pilots from each antenna; 2) MS estimates the associated DL channels, computes the differential CSI and segments the Pha & Amp (or Re + j Im) information; 3) MS transmits the segmented information in successive bursts; 4) BTS receives and decodes (reconstructs) the segmented information.

A complex coefficient of the form $Amp\angle Pha$ is to be transmitted by exploiting N consecutive slots. A partition of N is done in such a way that the first N_1 slots carry phase information and the remaining N_2 slots carry amplitude information. In principle N_1 and N_2 can be arbitrarily chosen, the only restriction being ($N = N_1 + N_2$). A common value for these parameters could be $N_1 = N_2 = N/2$. It is assumed that each slot has reserved K bits for conveying CSI information.
The phase can be resolved with an accuracy of

$$(Pha)_{min} = \frac{360}{2^{N_1K}} \; [°], \qquad (1)$$

and the amplitude

$$(Amp)_{min} = \frac{A_{max}}{2^{N_2K}}, \qquad (2)$$

where A_{max} is the maximum amplitude.

Example 1
$N = 6, N_1 = N_2 = 3, K = 1$ (1bit/slot) and $A_{max} = 3$. The accuracy in the phase and amplitude are:

$(Pha)_{min} = 45°$ and $(Amp)_{min} = 0{,}375$

Example 2
$N = 6, N_1 = N_2 = 3, K = 2$ (2bits/slot) and $A_{max} = 3$. The accuracy in the phase and amplitude are:

$(Pha)_{min} = 5{,}6°$ and $(Amp)_{min} \cong 0{,}05$

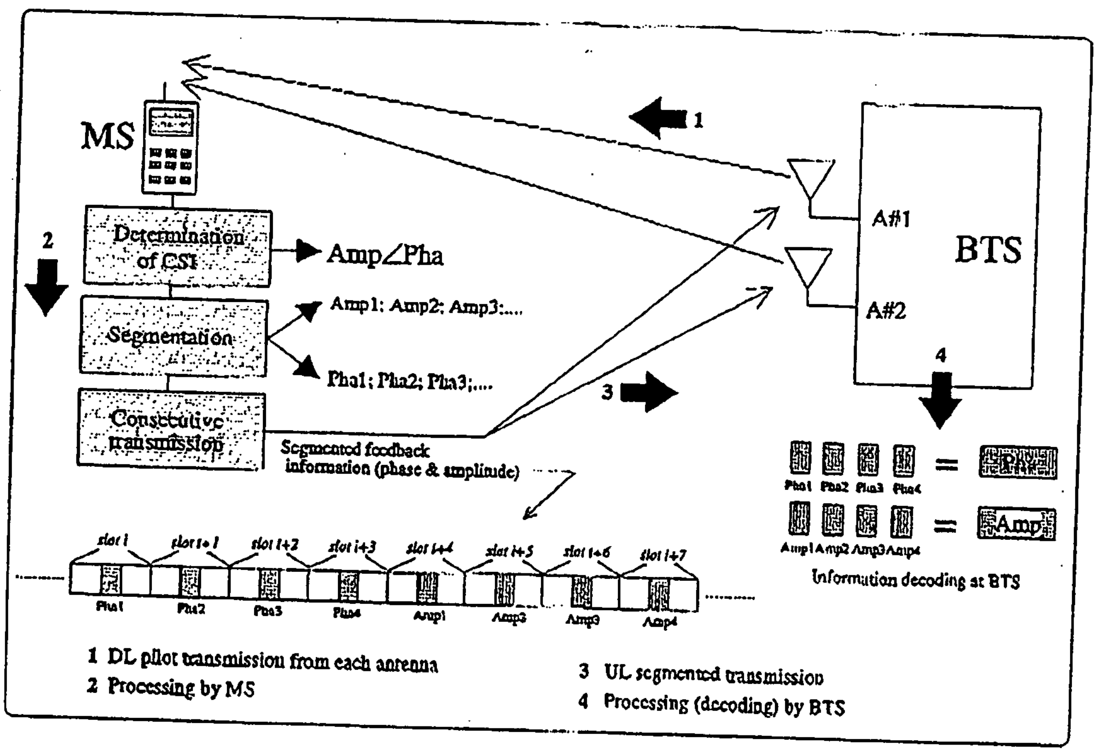

Figure 1. Principal description of the proposed segmented feedback method for improved downlink performance.

In general Pha$i$, $i = 1,2,\ldots, N_1$, (Amp$i$, $i = 1,2,\ldots, N_2$), contains partial information of the exact Pha (Amp) figure and it is transmitted in an hierarchical order. Thus, Most Significant Bits (MSB) are transmitted in first place and Least Significant Bits (LSB) in the last order.

Some analysis and an example

In the following an example is given which clarifies the proposed method. Assume that a MS is moving at a speed of v=1 m/s (3.6 km/h) and the carrier frequency is 2 GHz ($\lambda = 0.15$ m). Then the coherence time of the channel can be calculated as

$$T_c = 1/(2 f_D) = \lambda/(2 v) = 0.15 \text{ m}/ (2 \text{ m/s}) = 75 \text{ ms} \quad (3)$$

where f_D is the maximum Doppler frequency (=v/λ). It can be presumed that during $T_c/10$ the channel has not changed significantly and thus one could use 7.5 ms for transmitting the CSI information. Since in WCDMA the slot duration is 0.625 ms one could use 12 slots to feed back the CSI information. There are different possibilities in arranging the feedback. If only one bit/slot is allowed (K = 1) then one could send first a few slots with phase information and then a few slots with amplitude information as shown in Table 1:

Slot#	1	2	3	4	5	6	7	8	9	10	11	12
FB bit	Phase MSB	Phase MSB	Phase Bit 2	Phase Bit 2	Phase LSB	Phase LSB	Amp MSB	Amp MSB	Amp Bit 2	Amp Bit 2	Amp LSB	Amp LSB

Table 1. An example of using consecutive slots in feedback for improving recursively the accuracy of DL beamforming weights.

In Table 1 three-bit accuracy is used for both the phase angle and amplitude information. In the beginning the phase information is transmitted in a way that first the most significant bit is sent. Then the same bits is repeated (to improve reliability). After that the other phase angle bits and the amplitude bits are sent in a similar fashion. First bit gives the phase accuracy of 180° as in 1-bit mode of TX-AA and after 3 and 5 slots the phase accuracy becomes 90° and 45°, respectively.

Trade-off between the allowed feedback capacity (one or more bits/slot), the feedback reliability (# of repeated bits) and the feedback accuracy (# of phase angle and amplitude bits) has to be made.

If it is assumed that the phase angle changes approximately 360° during the coherence time of the channel then in the above example the phase angle change in 7.5 ms is about 36° . This corresponds well to the phase accuracy of 45° (3 bits).

In general, the phase angle information is more important (equal-gain combining performs only about 1 dB worse than MRC) and thus one could use more phase angle bits than amplitude bits. In principle, a phase error of $2\pi/8$ is acceptable /1/. Then one possibility could be to send 3 phase angle bits and 2 amplitude bits so that a minimum duration for feedback would be 5 slots (in WCDMA this corresponds to 3.125 ms).

Advantages/disadvantages and application areas

The proposed method improves the DL performance due to better phase angle and amplitude accuracy in DL beamforming (the method approaches MRC combining in DL). The method operates best in environments with

- Low mobility
- Low diversity (1-tap channel),

Therefore, the method suits best for high data rate applications in indoor and pedestrian environments. The proposed scheme is particularly appropriated to be used with high bit-rate wireless data applications for laptop computers.

Like any other feedback diversity modes the performance of the proposed method degrades in high mobility (vehicular) environments when the radio channel is changing rapidly.

Some other comments

It is pointed out that the proposed method can be employed in base stations exploiting either beamforming techniques (e.g. antenna array with interelement separation of $\lambda/2$) or antenna diversity (e.g., large antenna separation or antennas with different polarisation)

Note than in principle the proposed method can operate in two different fashions. BTS can either use the information as it is received and improve it gradually as new segments are received or, on the other hand, it can receive the whole segmented sequence to then effectively utilize the precise CSI.

References:

/1/ O. T. Von Ramm, "Beamsteering with linear arrays", IEEE Trans. BME, vol. 30, no. 8, 1983.

EXHIBIT B

Communication between Inventors and Drafting Attorney
Demonstrating Diligence

(Comments Redacted)

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May 17, 2000

Mr. Juha T. Ylitalo
Nokia Networks Oy
P.O. Box 319
FIN-90651 OULU, FINLAND

VIA FEDERAL EXPRESS

Re: **Closed Loop Feedback System**
For Improved Down Link Performance
Nokia Ref.: NC 23282
Our Ref.: 4770.81503

Dear Juha:

Thank you for your May 8 facsimile letter and your May 10 e-mail. I have enclosed a revised patent application

EXHIBIT C

Copy of Executed Joint Declaration for Patent Application Demonstrating Diligence

JOINT DECLARATION FOR PATENT APPLICATION

OIPE JC98 JUL 2 0 2005 PATENT & TRADEMARK OFFICE

As the below named inventor, we hereby declare that:

Our residence, post office address and citizenship are as stated below next to our names;

We believe we are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled CLOSED LOOP FEEDBACK SYSTEM FOR IMPROVED DOWN LINK PERFORMANCE

the specification of which

■ is attached hereto.

☐ was filed on ________ as Application Serial Number ________ and was amended on ________ (if applicable).

We hereby state that we have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

We acknowledge the duty to disclose information which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Prior Foreign Application(s)

We hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Country	Application Number	Date of Filing (day, month, year)	Date of Issue (day, month, year)	Priority Claimed Under 35 U.S.C. §119

Prior United States Application(s)

We hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, we acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial Number	Date of Filing (Day, Month, Year)	Status — Patented, Pending, Abandoned

Prior United States Provisional Application(s)

We hereby claim priority benefits under Title 35, United States Code, §119(e) of any provisional application for patent listed below and have also identified below any provisional application for patent having a filing date before that of the application on which priority is claimed:

Provisional Application Number	Date of Filing (day, month, year)	Priority Claimed Under 35 U.S.C. §119(e)

And we hereby appoint, both jointly and severally, as our attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith the following attorneys who are all members of the Bar of the District of Columbia, their registration numbers being listed after their names:

Donald W. Banner, Registration No. 17,037; Edward F. McKie, Jr., Registration No. 17,335; William W. Beckett, Registration No. 18,262; Dale H. Hoscheit, Registration No. 19,090; Joseph M. Potenza, Registration No. 28,175; James A. Niegowski, Registration No. 28,331; Joseph M. Skerpon, Registration No. 29,864; Thomas L. Peterson, Registration No. 30,969; Nina L. Medlock, Registration No. 29,673; William J. Fisher, Registration No. 32,133; Thomas H. Jackson, Registration No. 29,808, Daniel E. Fisher, Registration No. 34,162 and Bradley C. Wright, Registration No. 38,061.

All correspondence and telephone communications should be addressed to: Banner & Witcoff, Ltd., Eleventh Floor, 1001 G Street, N.W., Washington, D.C. 20001-4597, telephone number (202) 508-9100, which is also the address and telephone number of each of the above listed attorneys.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signature Juha Ylitalo Date 5/25/00

Full Name of First Inventor Ylitalo (Family Name) Juha (First Given Name) (Second Given Name)

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Citizenship Finland

Post Office Address SAME AS ABOVE

Signature Marcos Katz Date 5/25/00

Full Name of Second Inventor Katz (Family Name) Marcos (First Given Name) (Second Given Name)

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